Technical Memorandum
Panoche Energy Center

Expanded Evaluation of Water Supply and Wastewater Discharge Alternatives –*March 2, 2007*

1.0 Background and Purpose

This Technical Memorandum follows and responds to discussions between California Energy Commission (CEC) staff and the Panoche Energy Center (PEC) at the January 31, 2007 Data Response and Issues Resolution Workshop. Specifically, CEC staff requested additional evaluation of the water supply and wastewater disposal alternatives and additional evidence to support PEC's Application for Certification (AFC) determination that use of the lower aquifer water for power plant cooling and emissions control is the best option. Further, CEC staff expressed concern about the timing of the U.S. Environmental Protection Agency's (EPA's) issuance of the Class I Non-hazardous Underground Injection Well (UIC) Permit relative to the CEC schedule, and the lack of evidence showing that the PEC's UIC design will work. Consequently, the PEC was asked to conduct further evaluation of the supply water and wastewater disposal alternatives and present "substantial evidence" that the selections presented in the AFC indeed are the most feasible environmental and economic options available.

This Technical Memorandum summarizes the PEC's additional study and analysis of the water and wastewater alternatives that consider environmental and economic impacts in the context of Laws, Ordinances, Regulations, and Standards. In doing so, the PEC believes that the original water management plans as detailed in the August 2, 2006 AFC are further validated. This memorandum provides a detailed description of the various water supply and wastewater disposal options and includes a thorough evaluation of the regulatory, technical, and economic feasibility of these options.

2.0 Project Description and Objectives

The PEC project is defined as a peaking and/or "load shaping" plant. The purpose of such a project is to provide electric power on very short notice to meet unexpected high demands from consumers. Pacific Gas & Electric (PG&E) issued a long-term Request for Offer (RFO) for Power Purchase on March 18, 2005. The RFO specifically states that "PG&E is seeking peaking and/or shaping products." The PEC was conceived as a result of this RFO. The load shaping products, such as the proposed PEC, provide PG&E with the ability to dispatch the plant whenever it deems necessary to meet fluctuating retail load. It should be noted that PG&E pays for only the capacity of the plant, at a prenegotiated rate, but the PEC is obligated to deliver guaranteed electrical output when PG&E dispatches the units. Load shaping products typically have low annual capacity factors as they are only on-line at times of high electricity demand. The absence of such peaking and load shaping resources can potentially result in rolling black-outs for residential, commercial, and industrial consumers.

The PEC has been designed to assure that the plant will deliver the guaranteed output to PG&E in accordance with the requirements of the contract between PEC and PG&E. The PEC is required to meet certain minimum conditions, which require:

1. A continuous, reliable and good quality water resource for plant cooling and other process applications; and
2. A reliable and environmentally sound wastewater disposal method.

It is important to note that during the evaluation phase of the project, the PEC considered the use of dry cooling to minimize water use since water supply of good quality is not abundantly available at the site. However, considering the location and the weather conditions at the site, this option was ruled out as being not practical since the ambient temperatures during summer when power is in high demand can reach up to 114 degrees Fahrenheit (ºF). The plant's output would fall precipitously at those ambient temperatures if dry cooling was utilized. In other words, during peak conditions when the PEC is contractually required to deliver certain megawatts (MW) of power to the grid, the PEC would not be able to provide sufficient cooling to the plant to in order to produce the required amount of electricity. The reasons for the shortfall in electricity generation under an air cooled scenario are described in more detail below.

The PEC proposes to install a high-efficiency combustion turbine for power generation. GE's LMS100 is a unique technology designed to utilize an intercooler for the inlet air as it is compressed, allowing for approximately 10% greater thermal efficiency than existing commercial simple cycle peaking units. This design also requires an efficient methodology to reject the intercooled air heat under peak ambient conditions consisting of air temperatures of 114 ºF.

The PEC conducted an evaluation of a "dry cooling" design versus the proposed plant design of water cooling. Power output at 114 ºF is 81 MW lower (i.e., 20% less) for a dry cooled plant than with a cooling tower and evaporative coolers. For a plant design with dry cooling, the PEC would have to install a fifth LMS100 turbine at an estimated cost of $70M to meet the power generation shortfall and satisfy the contractual requirements with PG&E.

In summary, after comparing dry cooling and water cooled systems, the following conclusions were reached:

1. A dry cooled system would require an additional turbine to be installed for the same power output under peak conditions; and
2. For a dry cooled system, the increase in fuel burned per MW produced would also result in increased air pollutant emissions by up to 20% under peak conditions.

Due to the estimated $70M additional cost for installation of a fifth turbine for the same output , the use of dry cooling is economically unsound for this project.

3.0 Project Water Supply

3.1 Project Water Supply – Guiding Principles

The state of California has adopted policies regarding the use of inland waters for power plant cooling. These policies require that fresh water be conserved and used for power plant cooling only if other water sources are environmentally undesirable or economically unsound. The 2003 Integrated Energy Policy Report (page 40) stated that the CEC has responsibility "to apply state water policy to minimize the use of fresh water, promote alternate cooling technologies and minimize or avoid degradation of the quality of the state's water resources." In the CEC Final Decision in the Consumnes Power Plant Project (01-AFC-19), the Commission summarized the requirements of California Water Code section 13550 et seq. and California State Water Resources Board Resolution 75-58, "…the use of potable or fresh inland water for power plant cooling as an unreasonable use and only to be used if other sources or other methods of cooling would be environmentally undesirable or economically unsound" (Page 206). This guidance leads to the following three areas of discussion of the Applicant's water supply: 1) Is the water source "fresh," 2) Does the water supply comply with the "cascading" requirements of Resolution 75-58, and 3) Will the project minimize the degradation of the state's waters. Finally, if the project would cause a significant impact upon the environment, a range of alternatives must be considered.

The cascading requirements of the Resolution 75-58 are as follows:

- Wastewater being discharged to the ocean;
- Ocean water;
- Brackish water from natural sources or irrigation return flow;
- Inland wastewaters of low total dissolved solids (TDS); and
- Other inland waters.

3.2 Project Water Supply - Alternatives

3.2.1 Surface Water

As stated in the AFC, sources of surface water large enough to meet the PEC's needs are not located in sufficient proximity to the site for consideration as a source of water supply.

3.2.1.1 Ocean Water

Due to the distance of the PEC from the Pacific Ocean, as well as the high concentrations of TDS, this alternative was dropped from further consideration. (See "Surface Water" above.)

3.2.1.2 SWP Water

The California Aqueduct, a joint use Storm Water Project /Central Valley Project (SWP/CVP) facility (the CVP share is known as the San Luis Canal), is located three miles east of the PEC site. This aqueduct receives flows from the Sacramento-San Joaquin River Delta and the San Luis Reservoir. Water available from the SWP is of superior quality, with TDS levels averaging about 250 to 300 milligrams per liter (mg/L). This compares to 860 to 1,100 mg/L in the confined aquifer and greater than 2,900 mg/L in the semi-confined aquifer beneath the PEC site. However, the PEC site lies outside the State Water Resources Control Board Designated Permitted Place of Use for SWP water. Therefore, SWP water cannot legally be delivered to the PEC site. Further, as stated in the AFC, the Applicant determined that use of potable water from the California Aqueduct is inconsistent with the priority of use of water supplies for power plant cooling identified in the State Water Policy, since lower quality water is available at the PEC (i.e., lower aquifer water). Consistent with the PEC AFC, this SWP alternative was eliminated from further consideration. No further information is available to change this conclusion.

3.2.1.4 Federal CVP Water

Federal CVP water in the PEC area is conveyed via two facilities. First is the Delta-Mendota Canal a CVP-owned facility, the terminus of which is located 1 mile north of the City of Mendota, about 18 miles from the PEC. Second, as noted above, CVP water is also conveyed in the San Luis Canal, the federal share of the joint use facility also known as the SWP California Aqueduct. As stated in the AFC, in 2002, Westlands Water District Board of Directors made a determination that no new nonagricultural service connections would be served if annual water use was going to be more than 5 acre-feet. According to available information, Westlands has not changed its position in this matter. Further, as stated in the AFC, the Applicant determined that use of potable water from the SWP California Aqueduct/CVP San Luis Canal is inconsistent with the priority of use of water supplies for power plant cooling identified in the State Water Policy, as brackish water is available at the PEC. This alternative was eliminated from further consideration. No further information is available to change this conclusion.

3.2.1.5 Reclaimed Water

Reclaimed water (i.e., wastewater receiving tertiary treatment) is not available in the vicinity of the PEC. The wastewater treatment plants (i.e., Publicly Owned Treatment Works [POTW]) closest to the PEC are:

1. The City of Mendota, located approximately16 miles from the site, has a wastewater treatment capacity of approximately 1.2 million gallons per day (MGD) (based on a monthly average). The Mendota POTW does not have capacity to generate reclaimed water at this stage.
2. The City of Firebaugh, located approximately 25 miles from the site, has a wastewater treatment capacity of 1.5 MGD, and only provides secondary treatment. It produces limited amounts of water for recycling that is mostly used locally by farmers for non-food irrigation. Currently, it has no reclaimed water capacity to spare for additional usage, such as for the PEC project.

In summary, reclaimed water use is not feasible because of the distance to the reclaimed water sources and their lack of capacity.

3.2.2 Agricultural Water (Irrigation Return Flows)

There are two general categories of irrigation return flows in the general vicinity of the PEC. These categories, subsurface drainage and surface return flows, are discussed as follows.

Subsurface Drainage

Wastewaters from subsurface agricultural drains in the project area, the closest active systems being about 10 miles away, generally exhibit high levels of selenium, magnesium, and other dissolved solids that are considered toxic to fish and other wildlife. Previous evaluations have determined that treatment of these wastewaters to make them suitable for disposal would cost approximately $3,000 to $4,000 per acre-foot. No estimates are available for additional treatment sufficient to allow reuse. Further, the Westlands Water District's experience with water that was conveyed by the San Luis Drain has shown significant encrustation and has highly corrosive and abrasive qualities that damaged pumps and related equipment beyond simple repair/maintenance after only a few thousand hours of operation.

The San Luis Drain is 14 miles from the PEC site and is 265 feet lower in elevation. As reported by the Fresno Bee, February 2007, all discharges of shallow groundwater to the San Luis Drain were terminated in August 1986 under court order and state regulatory actions. To meet this court order, Westlands Water District removed all shallow groundwater drainage pumps and installed about 100 semi-permanent plugs in the drainage collector system pipelines. In addition, many growers who formerly had drainage service installed plugs in their farm drainage collection systems. Therefore, there is no longer any shallow groundwater in the San Luis Drain within the Westlands Water District.

In addition, all lands previously discharging shallow groundwater to the San Luis Drain and other surrounding areas are subject to a litigation settlement land retirement program. The United States Bureau of Reclamation and Westlands Water District have already retired approximately 125,000 acres from agricultural production in the project area and are currently considering a proposal that would lead to the retirement of up to an additional 275,000 acres in this general area due to the absence of feasible alternatives to treat and manage these wastewaters. Once retired, and lacking irrigation, there is no longer shallow groundwater emanating from these lands. Therefore, even if the subsurface water could be treated, the pipeline plugs removed, the drainage pumps reinstalled, and farm drainage systems restored and court orders and regulatory actions overcome, there would be no water entering the San Luis Drain absent the now retired land being returned to production, which could be in violation of the litigation settlement to keep the lands out of irrigated agricultural production. This water supply alternative was eliminated from further consideration. No further information is available to change this conclusion.

Surface Return Flows

The second category of irrigation return flows is surface runoff from furrow, flood, or other irrigation practices. Due to the high cost of water in the project area, tailwater collection and reuse systems are extensively employed to collect, convey, store, and recycle surface runoff from irrigation practices. However, due to the high cost of water supply, most land in agricultural production in the project area uses aboveground or buried drip, microsprinkler or sprinkler irrigation methods that normally do not generate surface runoff. The extent to which any runoff is produced, the water is normally recycled in the irrigation process. If this water was used for any other purpose, such as PEC cooling water, it would have to be replaced with an equal quantity of surface water. As noted above, much of the agricultural lands that previously discharged irrigation tailwater have been retired from production due to concerns regarding selenium contamination of the underlying shallow groundwater.

Use of Agricultural water recovery was investigated in October, 2005 for the PEC project. Baker Farming, the agricultural operation site adjacent to the PEC, utilizes a drip irrigation and micro sprinkler irrigation systems which do not typically produce any "runoff." However, each quarter section of land contains a filtration system that must be backwashed periodically. Baker Farming, like other farms in the PEC area, has developed a system to recover this backwash water and reuse it for irrigation. The PEC held discussions with Baker Farming about the potential of using this water for the project. Baker Farming recovers backwash water at a volume equivalent to about one-third of the water supply needs of the PEC, but not necessarily at the times required. This alternative is therefore not feasible because the water supply would be inadequate. However, this potential source of water supply was dropped from consideration when it also became evident that Baker Farming would be required to replace (offset) water supplied to the project with additional water from fresh water sources, thus defeating the purpose of not using fresh water sources for power plant cooling.

Use of surface runoff was eliminated as a water supply alternative because it was determined to be not feasible and environmentally undesirable.

3.2.3 Groundwater

The aquifer system comprising the Westside Subbasin consists of unconsolidated continental deposits of Tertiary and Quaternary age. These deposits form an unconfined to semi-confined aquifer overlying a confined aquifer, as shown on Figure 3.1. These aquifers are separated by an aquitard that is composed of the Corcoran Clay member of the Tulare Formation.

Suitability of groundwater as a project water supply alternative for the PEC has been evaluated on the basis of groundwater quality and availability within the two aquifers underlying the site. Groundwater quality has been evaluated using data from two sets of groundwater samples collected from monitoring wells installed at the PEC site, reported data from an adjacent site, and published data for the surrounding area. Groundwater availability was evaluated using the performance of agricultural irrigation wells formerly common in the area and the groundwater model prepared for the PEC site, as described below.

As part of the production water assessment, a groundwater flow model was compiled to simulate groundwater underlying the PEC site and surrounding area. The groundwater flow model was developed using the Brigham Young University Environmental Modeling Research Laboratory (EMRL) Groundwater Modeling System (GMS), Version 6.0 (EMRL, 2006). GMS is a comprehensive graphical user interface (GUI) for performing groundwater simulations that utilize several groundwater modeling codes, including MODFLOW and MODPATH. The GMS was used to develop a site conceptual hydrogeological model and to convert it into a 3-D groundwater flow model. Several reasonable and practical assumptions, based on field conditions and professional judgments, are required for the model. The model is divided into three layers that represent the semi-confined aquifer (layer 1), the Corcoran Clay (layer 2), and the confined aquifer (layer 3). Model layers 1 and 2 are simulated as unconfined aquifers, and model layer 3 is simulated as a confined aquifer. The starting heads for the model were calculated from a recent groundwater investigation performed for PEC site (URS, 2006) and local groundwater elevation maps (Westlands Water District, 2001). Additional data used to construct the groundwater model were obtained from the Groundwater Flow in the Central Valley Report (Williamson et. al., 1989). This model was introduced in the response to CEC Data Request 47 and has been modified based on recently acquired hydraulic conductivity estimates described in Section 3.2.7.2.

3.2.3.1 Semi-Confined Aquifer Water Quality

Groundwater samples collected from an on-site monitoring well (i.e., MW-3) screened from 440 to 460 feet below ground surface (bgs) indicate that groundwater quality within the semi-confined aquifer underlying the site is impacted by relatively high concentrations of several constituents including TDS, sulfate, hardness, and silica (Tables 3.1 and 3.2). Multiple constituents exceed published water quality limits, including California Department of Health Services (CDHS) and EPA's Primary and Secondary Maximum Contaminant Limits (MCLs) and agricultural water quality limits (Regional Water Quality Control Board [RWQCB], 2003).

Figure 3.1

Table 3.1

Table 3.2

Data from groundwater samples collected from monitoring well MW-3 are consistent with reported data for the CalPeak Panoche well located approximately 2,000 feet northeast of the PEC site. The CalPeak Panoche well is screened from 440 to 500 feet bgs and the filter pack extends from 20 to 500 feet bgs. The well is completed within the semi-confined aquifer. TDS, sulfate, hardness, and silica concentrations reported for a groundwater sample from the well are 3,400 mg/L, 1,900 mg/L, 1,500 milligrams equivalent calcium carbonate (mg equiv. $CaCO_3$), and 47 mg/L, respectively (Starwood, 2006). All of these concentrations are higher than those reported for PEC monitoring well MW-3, which is likely the result of the well producing lower quality groundwater from higher elevations within the semi-confined aquifer. A supply well completed within the semi-confined aquifer at the PEC site would be expected to produce similar water to the CalPeak Panoche well.

Sulfate concentrations exceeding 1,500 mg/L and hardness greater than 1,200 mg equiv. $CaCO_3$ are of particular concern for operation of the PEC. The sulfate and hardness concentration limits for the cooling tower design are 900 mg/L and 500 mg equiv. $CaCO_3$, respectively. Significant pretreatment to reduce concentrations of these constituents would be required prior to using the groundwater in the plant, even for a single cooling cycle.

Cycling cooling water multiple times is fundamental to the design of the PEC. Once-through cooling would cause efficiency losses of about 1.5 MW per unit because the heat rejection system of the plant would require redesign to incorporate an additional heat exchanger. Further, fewer cycles of cooling associated with use of water from the semi-confined aquifer would require more water to be extracted, treated, used for cooling, and injected as waste. Treatment and reuse of this cooling water to allow additional cycles of concentration would not be economically feasible because initial concentrations of sulfate and other constituents in the groundwater are high and would be further concentrated by the cooling process.

The only effective pre-treatment method is a lime softening system to remove suspended and dissolved solids, hardness, and alkalinity. The pretreatment system would need to be sized for the entire plant supply of 1,254 gallons per minute (gpm). This design would require extensive treatment of all water, including 591 gpm (47% of the supply) that will evaporate in the cooling tower. Industrial lime softening systems are designed for continuous operation and take approximately 24 hours to start up. They are unsuitable for start-stop operation. Therefore a 2,000,000-gallon capacity treated water storage tank would be required to provide start-up water while the lime softening system is brought on line. In the event tank contents are depleted during plant operations, the lime and soda ash softening system would require a one- to two-day restart process. Incorporation of a lime softening system would incur environmental impacts related to the transport, delivery, and storage of lime and soda ash as well as the unloading, transport, and delivery (to landfill) of sludge. [Refer to section 4.2.1.)

Incorporation of a lime softening system to treat sulfate, hardness, and alkalinity at the levels encountered in groundwater within the semi-confined aquifer underlying the PEC is incompatible with the plant design and PG&E requirements that mandate the plant to be up to full load in 10 minutes. Further, this pretreatment system would cost approximately $20M to install. Annual operations and maintenance costs for this Alternative are estimated to be $3.2M. The PEC cannot sustain these added costs and remain viable under the pricing model that was used to secure the PG&E contract.

3.2.3.2 Semi-Confined Aquifer Water Availability

A reliable supply of groundwater capable of producing approximately 1254 gpm of raw water is required for the PEC during average plant operations. Groundwater availability within the semi-confined aquifer was assessed using the steady-state groundwater flow model prepared for the PEC site. The model incorporated aquifer hydraulic conductivity parameters specific to the shallow aquifer estimated using slug test data from monitoring well MW-3 at the PEC. Slug tests are not generally as accurate as performing a long-term pumping test, but are an efficient method to determine aquifer properties and can be used to estimate the hydraulic conductivity of the formation in the immediate vicinity of the well screen.

Slug tests were conducted in the well using the following method. The static water level was measured using an electronic water level meter and a pressure transducer was installed in the well. Four slugs, ranging from 1 liter (L) to 18.9 L of deionized water, were injected through tubing that was inserted inside the well and suspended close to the water surface to reduce splashing. Changes in water-level data were recorded with the pressure transducer and monitored in real time at the ground surface. Each test was terminated after the water level had recovered to nearly the original static water surface measurement. Changes in water level data were analyzed using the Unconfined/Confined High Conductivity Bouwer-Rice Solution (Springer and Gelhar, 1991), the Confined - Hvorslev Model (Butler, 1997) and the Uffink method for oscillation test data to estimate a value of hydraulic conductivity (K) for the aquifer. Data from the smallest (1 L) and largest (18.9 L) slugs were not used in the analysis because the slugs were too small and took too long to inject, respectively. The hydraulic conductivity estimates ranged from 15.8 to 27.6 feet/day, which is within the normal range for the silt and sand semi-confined aquifer material encountered within the semi-confined aquifer (Freeze and Cherry, 1979). This site-specific hydraulic conductivity value range was incorporated into the steady-state groundwater model. Hydraulic conductivity is a normalized variable that describes the rate at which water can move through a given area in an aquifer and is a basic parameter used in groundwater flow modeling (URS, 2007a).

A production well with a 250-foot screened interval was added into the model to simulate operation of a supply well within the semi-confined aquifer. The pumping rate design was assumed to be 1,254 gpm over a 5,000-hour period (the maximum annual operation period of the PEC), which equates to an annualized rate of approximately 642 gpm in the steady state model. The model indicates that sufficient simulated groundwater production from the semi-confined aquifer would likely adversely impact wells screened in the semi-confined aquifer within a one-mile radius of the PEC. The predicted radial extent of a 10-foot drawdown impact is approximately 2,640 feet and the predicted radial extent of an 8-foot drawdown impact is 5,280 feet. Progressively smaller drawdown would extend greater distances from the PEC.

As many as 12 existing or abandoned water wells have been identified within a one-mile radius of the PEC. Most of these wells have been abandoned, have collapsed, or are monitoring wells not used for groundwater production. The closest known supply well completed in the semi-confined aquifer is the CalPeak Panoche Plant well. The estimated yield of the well was 100 gpm based on a 1-hour test with no drawdown reported (Starwood, 2006). Based on the drawdown analysis, this neighboring supply well would likely be adversely impacted by approximately 10 feet of drawdown if a PEC supply well installed within the semi-confined aquifer was pumped at an annualized rate of 642 gpm. Any drawdown in neighboring wells could be considered adverse because it would increase operational costs for the wells. Assuming an overall efficiency of 65%, power requirements for pumping a well would increase about 0.39 kilowatts per foot of drawdown. Based on PG&E agricultural rates (Schedule AG-1, Rate B, Effective 9/1/2006), pumping costs would increase about $0.292 per acre foot of water pumped per foot of drawdown.

An additional factor in groundwater availability is the reliability of the PEC supply wells. Relatively high concentrations of sulfate, along with other minerals dissolved in the semi-confined aquifer groundwater, would be expected to cause significant encrustation, corrosion, and abrasion of pumps and related equipment leading to above average repair and maintenance requirements and costs. The potential for downtime of the supply wells and possibly the PEC itself would increase if the semi-confined aquifer was the selected water supply alternative. Sufficient quantities of groundwater for the PEC appear to be present in the semi-confined aquifer, although production operations may have some impact on neighboring well production. ***Therefore, obtaining production water from the semi-confined aquifer was eliminated because the low quality water is expected to adversely affect the site operational costs and may negatively impact the production operations of nearby wells.***

3.2.3.3 Confined Aquifer Water Quality

Groundwater samples collected from on-site monitoring wells screened from 1,100 to 1,120 feet bgs (MW-2) and 1,302 to 1,322 feet bgs (MW-1) indicate that groundwater quality within the confined aquifer underlying the site is negatively impacted by dissolved minerals (see Tables 3.1 and 3.2). Detected constituents in the groundwater samples collected from both the upper and lower portions of the confined aquifer were compared to water quality limits for drinking water and agricultural use published by the Central Valley RWQCB (RWQCB, 2003). The comparison was intended to indicate the suitability of the sampled groundwater for use as drinking water or agricultural water. Based on the analytical reports, the sampled groundwater appears to be a poor candidate for use as a drinking or agricultural water supply without treatment. The reported turbidity value may also exceed EPA and CDHS primary MCLs for drinking water, but may have been negatively influenced by air-lift pumping. Specific conductance and pH values, as well as TDS and iron concentrations, exceeded CDHS and/or EPA Secondary MCLs for drinking water and agricultural water quality limits. Detected concentrations of sulfate as SO_4 exceeded EPA Secondary MCLs for drinking water. Boron, molybdenum, and sodium concentrations also exceeded agricultural water quality limits.

While treatment would be required prior to using the water for cooling at the PEC, the treatment required would be at a lower cost than if the water was to be used for drinking water. Treatment of the water from the supply wells would be as described in the AFC and subsequent CEC data request responses and is a feasible method to supply water for the PEC. The concentrations of strontium, barium, silica, and iron are at levels that may cause fouling and scaling problems for the cooling towers.

3.2.3.4 Confined Aquifer Water Availability

Well yields within the Westside Subbasin of the San Joaquin Valley Groundwater Basin average 1,100 gpm and average from 600 to 1,800 feet in depth (DWR, 2004). Lithologic and geophysical logging of sedimentary deposits underlying the site indicates that geologic and hydrogeologic properties of the semi-confined and confined aquifer are consistent with the surrounding area and the aquifers should be capable of producing average groundwater yields.

As stated in the response to CEC Data Request 47, the groundwater model prepared for the PEC site indicates that a supply well pumping groundwater from the confined aquifer at an annualized rate of 750 gpm would not impact groundwater elevations within the confined aquifer or the overlying semi-confined aquifer. The model indicates that even if the annualized pumping rate was increased to 1,000 gpm, which is 33% higher than the proposed pumping rate, no noticeable drawdown occurs. An additional model run indicates that limited drawdown (i.e., less than 2.5 feet) occurs when the well is pumped at 2,000 gpm.

Sufficient quantities of groundwater appear to be present in the confined aquifer to meet PEC operational demands. Groundwater within the confined aquifer appears to present a reliable water supply suitable for the PEC based on previous use of this water for large-scale agricultural irrigation supply prior to delivery of surface water to the area.

Therefore, obtaining production water from the confined aquifer was retained for further consideration because the water, although not drinking-water quality, is of sufficient quality for PEC operations and there is an adequate supply with no potential negative impact on neighboring groundwater production operations.

3.3 Project Water Supply – Comparison of Alternatives

Table 3.3 presents a summary of the evaluation of water supply alternatives.

Table 3.3. .Summary of Water Supply Alternatives Evaluation

Environmental & Economic Measure		**Test 1** Is the supply feasibly available at PEC?	**Test 2** Will the alternative satisfy California Water Policy?	**Test 3** Is it technologically sufficient to guarantee high safety reliability?	**Test 4** Other Environmental Impacts	**Test 5** Capital Cost *	**Test6** Operation and Maintenance Annual Cost
Alt1	Surface water	Failed. Location is not close enough.	Would fail.	——	——	——	——
Alt2	State water project	2 miles away	Failed. PEC is located out of the permitted SWP area.	——	——	——	——
Alt3	Federal CVP water	Passed	Failed. The use of portable water is inconsistent with CVP.	——	——	——	——
Alt4	Reclaimed water	Failed. Available reclaimed water is located at least 25 miles away.	Passed	Failed. Currently reclaimed water is not available in sufficient quantity.	Pipeline to the PEC site would be required.	——	——
Alt5	Agricultural water	Passed	Passed	Failed. Agricultural water is not available in sufficient quantity.	Additional pumps, storage facilities, pipelines would be required.	$10M	$1.1M

Environmental & Economic Measure		**Test 1** Is the supply feasibly available at PEC?	**Test 2** Will the alternative satisfy California Water Policy?	**Test 3** Is it technologically sufficient to guarantee high safety reliability?	**Test 4** Other Environmental Impacts	**Test 5** Capital Cost *	**Test6** Operation and Maintenance Annual Cost
Alt6	Upper aquifer groundwater	Passed. However, there may be long-term supply issues.	Passed	Failed. High TDS concentration. Water quality will not meet minimum requirements. Water pretreatment would be economically and environmentaly unsound.	Energy efficiency losses would be generated, transportation of large quantity of chemicals, and large quantity of waste disposal.	$20M	$3.2M
Alt7	Lower aquifer groundwater	Passed	Passed	Passed. Sufficient quality to meet the water supply requirement for PEC.		$8M	$300k
Alt8	Ocean water	Failed. PEC islocated too far from ocean.	——	——	Pipeline would be required	——	——

* Cost are calculated on a rough order of magnitude level

4.0 Wastewater Disposal

4.1 Wastewater Disposal - Guiding Principles

In September 2006 PEC filed an application with the EPA in San Francisco for a permit to drill and utilize underground injection well(s) for disposal of the project's wastewater. In addition to deeming the Application "complete", EPA has not communicated any technical concerns with this Application. EPA has communicated to CEC and to PEC that the UIC application will be approved within one year or less from the filing date. CEC has expressed concern that the timing of EPA's issuance of the UIC permit (i.e., September 2007) and the PEC AFC process schedule set forth at the December 13, 2006 Informational Hearing. Given that UIC technology in general presents very low environmental risk, PEC believes that the CEC should consider proceeding with PSA and FSA by utilizing a "condition" that the UIC permit be issued to PEC prior to final approval of the AFC by the CEC.

The CEC staff has indicated that they would prefer to see the results of drilling in order to see if the deep well injection plan is feasible. There is no need to question EPA's determination; the CEC should give due deference to the federal government approval and accept the results of the EPA review of the filed application.

Alternatives to a proposed action are to be considered by the decision-maker which would "substantially lessen any of the significant effects of the project." [CEQA Guidelines, 14 CCR 15126.6(a)]. The deep injection well (UIC) offers the best wastewater alternative as it does not result in any significant environmental impacts; therefore, alternatives to the UIC wastewater disposal method are not required. However, PEC recognizes that the CEC must make its independent conclusion, and for that reason, additional information on wastewater disposal alternatives is provided below.

4.2 Wastewater Discharge - Alternatives

4.2.1 Zero Liquid Discharge

A zero liquid discharge (ZLD) power plant requires pretreating the process water discharge to remove the mineral content and recirculate the resulting liquid back into the process. For the PEC project, a ZLD system would be based on treating the maximum daily wastewater production anticipated and assumes that all plant wastewater, except sanitary wastewater and discharge from the oil/water separators, is routed to the cooling tower. The latter wastewater streams are assumed to be disposed of by leach field and land disposal, respectively.

The ZLD design concept is comprised of two major subsystems:

- Cooling tower blowdown pretreatment and concentration; and
- Brine crystallization and solids handling.

The cooling tower blowdown and concentration subsystem would include a High Efficiency Reverse Osmosis (HERO™) system for volume reduction. This process requires extensive pretreatment to remove suspended solids, hardness, alkalinity, and silica. The first step of the process treatment is lime and soda ash softening of a sidestream of the circulating water. The lime and soda ash softener is unsuitable for start-stop operation. Therefore a 1,000,000-gallon capacity cooling tower blowdown storage tank would be required to allow the lime and soda ash softening process to continue operating at steady state even when the plant is not operating. In the event tank contents are depleted during a plant outage, the lime and soda ash softening process would be shut down and would require one to two days for an orderly restart.

Approximately 400 gpm of the softened water from the side stream lime and soda ash softening process would be further treated by the HERO™ system. The HERO™ system should be able to recover approximately 90% of this waste stream with the reject stream going to the brine crystallization and solids handling subsystem.

The brine crystallization and solids handling subsystem was assumed to be ~ 40 gpm based on continuous operation and 90% recovery by the HERO™ process. Distillate from the crystallizer would be returned to the cooling tower. A portion of the recirculating slurry of salt crystals would be sent to the filter press for dewatering. Filtrate from the filter press would be returned to the crystallizer. The salt cake would be dumped into a hopper for off-site disposal via a truck transporter.

The ZLD system is complex and labor-intensive, as it requires continuous operator attention while in service. It is estimated that PEC would need to double its proposed staff from 12 to 24 personnel to be able to operate and maintain the ZLD system.

The lime softening, HERO™ and ZLD systems are designed to be continuous operations that take approximately 24 hours to start up. This is incompatible with the plant design and PG&E requirements that the plant be up to full load in 10 minutes. Keeping the ZLD system operational at all times, even when the power plant is not operational, changes the plant economics and makes it economically infeasible.

The lime softening system includes environmental impacts related to the transport, delivery and storage of lime and soda ash as well as the unloading, transport, and delivery (to landfill) of sludge.

In summary, the ZLD system is not suited to the needs of the PEC project for the following reasons:

1. It increases the capital costs of the project by about $21 million;
2. It increase the annual operating cost of the plant by about $2.4 million;
3. It handicaps the operating requirements of the plant by limiting plant readiness on demand; and
4. It adds to environmental issues due to increase in truck traffic and handling of additional chemicals and sludge hauling to a landfill.
5. The PEC cannot sustain these added costs and remain viable under the pricing model that was used to win the PG&E supply bid.

Numbers 1 and 2 above impact the economic feasibility of the project and Number 3 limits PEC ability to meet contractual requirements of the Power Purchase Agreement (PPA) and customer (PG&E) needs. ***Therefore, ZLD is economically unsound and environmentally undesirable..***

4.2.2 Evaporation Pond

An evaporation pond becomes viable if the waste stream can be reduced to a manageable quantity. However, the PEC waste stream is 394 gpm and would need to be reduced with a lime softening process and HERO™ system. As discussed earlier, this process is expensive and is not compatible with intermittent operations that must be able to achieve full load within 10 minutes. Discharge of the full waste stream would require a lined pond in excess of 100 acres, costing over $30M. PEC believes this is environmentally undesirable for wildlife due to the selenium concentrations in the area. Utilization of land for an evaporation pond went against the project objective to minimize conversion of agricultural land due to Williamson Act considerations. In addition, the landowner, Baker Farming, was not interested in making such additional acreage available for the project.
Therefore the evaporation pond was eliminated because it is economically unsound and environmentally undesirable.

4.2.3 Deep Injection Well

The application of a deep injection well system for facilities that generate brine requires optimum hydrogeologic conditions that can receive the injected waste without impacting potential groundwater resources within the site vicinity. Factors contributing to these optimum conditions include: the zone of groundwater injection is isolated from potential groundwater resources, the groundwater injection zone provides adequate storage for the injected waste, and formation water quality of the injection zone is low and not a potential groundwater resource. The Underground Injection Control Permit Application, submitted by PEC, provided a detailed assessment of these factors, which are summarized below.

- **Isolated Zone of Groundwater Injection**

  The PEC project site is located in the San Joaquin Basin, which contains a number of confining zones capable of protecting underground sources of drinking water. The proposed zone of groundwater injection beneath the site is within Eocene sands (Laguna and Cima) that extend from approximately 4,800 to 5,600 feet beneath the site. The sands are overlain by a laterally extensive, 900+ feet-thick shale sequence known as the Kreyenhagen Formation. This relatively impervious shale sequence acts as a confining zone that prohibits the vertical migration of high saline groundwater within the Eocene sands up to the shallower lower saline groundwater. In addition, there is no known faulting within the area of proposed injection that might affect the integrity of the Kreyenhagen Formation.

- **Adequate Storage for Groundwater Injection**

  Based on a detailed assessment of the Eocene sands at the nearby Cheney Ranch Gas Field, the injection zone transmissivity (assuming a minimum injection zone thickness of 500 feet) is approximately 765 ft^2/day with a corresponding storage coefficient of 0.00096. A detailed analysis of these conditions indicates that if PEC were to inject 765,000 gallons per day (which is more than the estimated volume for PEC operations), then the radius of wastewater spreading would be approximately ½-mile after 30 years of full-time operation. The corresponding pressure increase at this distance would be about 50 pounds per square inch or 115 feet of groundwater head, which is contained well within the overlying 900+ feet thick Kreyenhagen Formation. On the basis of these results, the proposed injection zone provides more than adequate storage for 30+ years of continuous operation with no potential impact to local groundwater supplies.

- **Injection Zone Formation Water is Not a Groundwater Resource**

  Analyses of groundwater collected from Eocene sands in the vicinity of the PEC site indicate that TDS are on the order of 22,000 mg/L. This concentration is well above the State Water Resources Control Board Resolution 88-63 usable municipal or domestic water supply limit of 3,000 mg/L. It is also above the maximum proposed injection concentration of 5,000 to 7,000 mg/L. Therefore, existing groundwater in the proposed injection zone is not considered a groundwater resource and will not be degraded by the proposed injection program.

It should be noted that several facilities meeting the above hydrogeologic factors have successfully implemented deep injection wastewater disposal using UIC Class I non-hazardous wells. One example is the Elk Hills power facility that currently injects over 1M gallons per day of brine into a relatively shallow injection zone. In addition, the Hilmar and Manteca cheese facilities have successfully installed and utilized UIC Class I non-hazardous injection wells for brine disposal under very similar hydrogeologic conditions as the PEC site.

The implementation of a deep injection well system at the PEC site would consist of two injection wells constructed to about 5,600 feet bgs with a continuous injection rate of about 284,000 gallons per day per well during site operations. PEC will operate as a peaker plant with an equivalent full-time operation of about four months per year. The installation cost for two wells is approximately $3M and the corresponding Operation and Maintenance costs are on the order of $100,000 per year.

Therefore, the Deep Injection Well alternative is the preferred method of wastewater disposal for the PEC.

4.2.4 Disposal to Wastewater Treatment Plant

As stated in the AFC, a POTW is not available in the vicinity of the PEC. The two nearest POTWs are 16 and 25 miles from the site (see Section 3.2.5 above) and, based on existing capacities, would be unable to accept another 0.57 MGD of wastewater. Both of these plants either have no current capacity to accept additional load or the projected load for the immediate future will leave them without extra capacity due to growth in the community.

This alternative was dropped from further consideration based unavailability of capacity and distance for the project site.

4.2.5 Surface Discharge

Based on the characterization provided in Table 5.5-13 of the AFC, wastewater from the PEC will not be suitable for surface discharge as it does not meet the water quality objectives specified in the Central Valley Region Basin Plan as shown in Table 4.1. Further, it is expected that the wastewater discharges will also not meet the requirements of the California Toxics Rule. Therefore, it has been determined that surface discharge will not be a feasible alternative for disposal of wastewater from the PEC.

Table 4.1 Comparison of Panoche Wastewater Characteristics and Basin Plan Objectives

Water Quality Parameter	Combined Flow Estimated Wastewater Characteristics	Basin Plan Objective
Boron	2.3 mg/L	1.0 mg/L
Chloride	250.7 mg/L	175 mg/L
Iron	1.2 mg/L	0.3 mg/L
pH	6.0 – 8.5	6-5 – 8.3 (without changing more than 0.3 units from normal ambient pH at any time)
TDS	1,668.2 mg/L	500 mg/L
Sulfate	536.8 mg/L	250 mg/L

Table References:

Central Valley Regional Water Quality Control Board. 2004. Water Quality Control Plan (Basin Plan) for the Tulare Lake Basin. Second Edition. Available at: http://www.waterboards.ca.gov/centralvalley/available_documents/basin_plans/TLBP.pdf

Central Valley Regional Water Quality Control Board. 2004. Recommended Numerical Limits to Apply to Water Quality Objectives. Available at: http://www.waterboards.ca.gov/centralvalley/available_documents/index.html#WaterQualityGoals

4.2.6 *Offsite Treatment*

The PEC will produce up to 567,400 gallons of wastewater per day while the plant is in operation. We could not identify a facility in the vicinity of the project site that can accept this amount of water for treatment.

Due to the large volume of wastewater, transport to a remote location for disposal was rejected due to economic, air quality and traffic considerations.

4.3 Project Wastewater Disposal – Comparison of Alternatives

Table 4.2 presents a summary of wastewater disposal alternatives.

Table 4.2. Wastewater Disposal Alternatives Summary

Environmental & Economic Measure		**Test 1** Is the wastewater disposal feasibly available at PEC?	**Test 2** Will the alternative satisfy applicable laws, ordinances, regulations and standards?	**Test 3** Is it technologically sufficient to guarantee high safety reliability?	**Test 4** Other Environmental Impacts	**Test 5** Capital Cost	**Test6** Operation and Maintenance (annual)
Alt1	Zero Liquid Discharge System	Passed	Passed	Failed. Low reliability, high energy ratings, high capital and maintenance costs, landfill disposal of wastes.	Transportation of large quantities of chemicals on site and waste hauling off-site.	$16M	$2.4M
Alt2	Evaporation pond	Passed	Failed. High selenium precludes permitting of such facility.	——	——	$30M	——
Alt3	Deep injection well	Passed	Passed	Passed	Passed	$3M	$100k
Alt4	Disposal to wastewater plant	Failed. Sewer is not available in the vicinity of PEC.	——	No POTW capacity available currently.	Pipeline to POTW will be required.	——	——
Alt5	Surface discharge	Passed	Failed. The quality of wastewater cannot meet federal discharge limitations.	——	——	——	——
	Offsite treatment	Passed	Passed	Failed. No off-site facility identified for this purpose.	Water will need to be transported off-site.	——	——

5.0 Summary and Conclusions

The PEC is a peaking and load shaping project that has certain requirements that have to be met without which the economic viability of the plant is compromised. One of the prime considerations of such a project is to provide electric power to the grid on very short notice to meet high demands from retail consumers and to comply with the terms of the PPA.

Since the shaping resources are expected to provide flexible operating capacity with energy production that can vary on a daily, seasonal, and annual basis depending on demand, and the cost of producing electricity, the operational requirements of load shaping products such as PEC vary, as do the operating economics of the plants.

PEC has to meet the essential requirements of the PPA to be able to dispatch electricity from "cold iron" to full load within 10 minutes. To fulfill these requirements, the project has to have continuous, reliable and good quality water resources for plant cooling/process applications and has to have in place a reliable and environmentally sound wastewater disposal option for the rejected water from the plant.

In this Technical Memorandum, we have provided supplementary information to justify the alternatives for both water supply and wastewater disposal. We have considered the full universe of available alternatives and by a process of elimination arrived at the best alternative for water supply and water disposal. In the process, we have followed rules and guidelines applicable for this process, considered environmental concerns, and applied criteria to help eliminate alternatives that do not serve the project objectives or run counter to water quality objectives of the state.

The selection of the confined lower aquifer presents the best option among the viable water source alternatives considering overall project and locale, environmental, health and safety, and economic performance.

UIC offers the best option for wastewater management and disposal among the wastewater alternatives considering overall project and locale environmental, health and safety, and economic performance.

6.0 References

Butler, J.J., Jr. 1997. The Design, Performance, and Analysis of Slug Tests. Boca Raton, Lewis Publishers.

California Department of Water Resources (DWR). 2004. California Groundwater Bulletin 118: San Joaquin Valley Groundwater Basin, Westside Sub-basin, February.

DWR. 2006. Delta Risk Management Study, San Joaquin Valley Groundwater Assessment. December.

EMRL, 2006. Groundwater Modeling System, Version 6.0. Brigham Young University.

Hill, M., E. Banta, A. Harbaugh, and E. Anderman, 2000. MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model; User Guide to the Observation, Sensitivity, and Parameter-Estimation Processes and Three Post-Processing Programs. Open-File Report 00-184. U.S. Geological Survey. Denver, Colorado.

Freeze, A.R. and J.A. Cherry. 1979. Groundwater. Prentice Hall, Englewood Cliffs, NJ.

Anderson, M., and W. Woessner, 1992. Applied Groundwater Modeling: Simulation of Flow and Advective Transport. Academic Press, San Diego, California.

RWQCB. 2003. A Compilation of Water Quality Goals. August.

Springer, R.K. and L.W. Gelhar, 1991. Characterization of large-scale aquifer heterogeneity in glacial outwash by analysis of slug tests with oscillatory response, Cape Cod, Massachusetts, U.S. Geological Survey Water Resources Investigation Report 91-4034, pp. 36-40.

Starwood. 2006. Application for Certification, Starwood Power-Midway, LLC Peaking Project. November.

URS. 2007a. Report of Monitoring Well Installation, Panoche Energy Center Site, Fresno County, California. January.

URS. 2007b. Hydraulic Conductivity Analysis and Model Update for Layer 1, Panoche Energy Center, Mendota, CA. February.

Westlands Water District. 2001. Groundwater Elevation Contours for Upper and Lower Aquifer. Maps are available at www.westlandswater.org under Water & Power, Groundwater and Maps.

Williamson, A.K., D.E. Prudic, and L.A. Swain. 1989. Ground-Water Flow in the Central Valley, Regional Aquifer-System Analysis, Central Valley, California, US Geological Survey Professional Paper 1401-D.